

Pest management for the home strawberry patch

Karl Foord, Jeff Hahn and Michelle Grabowski

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INTRODUCTION

Minnesotans who grow strawberries at home may have to combat insect pests or diseases to produce a good crop. Previous pest control strategies seeking to eliminate all pests from a garden have been shown to be unsuccessful. Today's approach combines many management methods into an integrated whole thus the name Integrated Pest Management (IPM). IPM practices have

enabled growers to place an emphasis on non-chemical methods while using pesticides secondarily or as a supplement to these methods while still harvesting quality fruit. The philosophy of IPM is to seek a balance maximizing yield while reducing human and environmental risk. This follows a particular hierarchy that begins with the best practices in cultural management.

PEST IDENTIFICATION AND BIOLOGY

To choose a proper management strategy, gardeners need to be able to identify pests and the damage that they cause. Gardeners can find additional help identifying common pest problems by using the online diagnostic tools [What insect is this?](#) and [What's wrong with my plant?](#) or by sending a sample to the [UMN Plant Disease Diagnostic Clinic](#). A hand lens can be helpful in identifying insects and pathogen signs as many are less than 1/4 of an inch. Once a pest has been identified, gardeners should learn about their biology. Understanding pest biology permits one to select the timeliest and most effective management strategy.

Thresholds

Research has shown that a certain level of disease and insect pest damage can be tolerated without reducing the number and quality of fruit harvested. However, pest damage can reach levels that are unacceptable. For some pests an action threshold has been established. The threshold is typically a number of insects or percent of damage on the plant that when reached, indicates that a grower should take action to prevent unacceptable damage. Thresholds are most commonly used in managing insect pest problems and information about thresholds for specific pests are included where appropriate.

Management

The foundation of a good IPM program begins with cultural practices that reduce pest populations and minimize diseases. Consider using pesticides when cultural control practices do not reduce pest damage to an acceptable level or as a supplement to these methods.

Site selection

By choosing the right site to grow strawberries, you can lower disease and insect pest pressure. Strawberries should be planted in well-drained soil that does not accumulate standing water following a heavy rainstorm. Planting on higher ground minimizes frost damage, while increasing air circulation around the strawberry plants. Good air circulation allows the berries to dry out faster, reducing the incidence of some diseases.

Resistant cultivars

Whenever possible select strawberry cultivars that have demonstrated resistance to common diseases like Verticillium wilt.

Best plant care

An IPM approach assumes that good care is being taken of the strawberry plants. Consult the University of Minnesota Extension publication [Growing strawberries in the home garden](#) for horticultural information. Good cultural practices—including site selection, cultivar selection, proper planting, irrigation, renovation, and frequent harvest—all contribute to a satisfying harvest each year. These practices seek to produce the healthiest plants by avoiding situations that favor

the development of diseases or contribute to insect infestations. Irrigation systems that avoid getting the leaf surfaces wet are preferred, such as drip systems or a soaker hose. If a sprinkler system is used, water plants in the mornings on a sunny day to allow leaf surfaces to dry quickly, reducing opportunities for fungal spore germination.

If possible, strawberries should be rotated to different areas of the garden every 3-4 years. Land that has been in strawberries for four years or more can build up a population of root-rotting pathogens. By moving the patch this can be avoided. Straw mulch reduces winter injury, and plants that have less winter injury have reduced disease. Straw mulch is equally important in the spring and summer as it reduces fruit and flower diseases by covering the soil and reducing spore movement carried by raindrop splash. When removing straw in spring, 1/2 to 1" of straw should be left between rows to keep fruit off the soil and reduce weeds.

Renovation

Renovation helps control diseases and insect pests by disrupting their life cycles. First, the plants are mowed and clippings removed. This helps to control diseases by removing older leaves that are infected by leaf spot or fruit rot pathogens. This helps to control insects by removing their food source and potential breeding sites. If plants are grown in rows, renovation is a good time to thin widening rows back to their original width. This will improve airflow through the patch and reduce the time that the leaf surfaces are wet, which can reduce disease severity. Regardless of the size and shape of your strawberry patch it is best to mow or cut the foliage back before August 1. A new canopy will develop by mid-August. To have a good crop in the following year requires healthy thriving plants from post-renovation to dormancy in the fall. Pay attention to the health of your plants in this time period.

Pesticides

In IPM, pesticide applications are used only when cultural controls are not effective or as a supplement to cultural controls. Before using a pesticide, be certain that you have correctly identified the pest organism and that the product you wish to apply is effective against that organism. Do not use products that are advertised as 'multi-use' or '3-in-1' to manage a single pest problem, as this would result in application of unnecessary pesticides.

If a pesticide is necessary choose one that is effective with the least ecological impact and environmental risk. Further information about pesticide application and safety can be found at the [Pesticide Environmental Stewardship](#) website and at the [National Pesticide Information Center \(NIPIC\)](#). Information on the correct way to apply specific pesticides can be found on the product label. If pesticides are necessary, always use them exactly as directed by the product label as mandated by federal law.

Table 1: Pest management schedule for June bearing strawberries

Time	Action
Early spring	Strawberry flower buds are very susceptible to spring frosts. Do not remove straw mulch used for winter protection until there is no longer a threat of frost. A good indication of this would be when lilac buds begin to open.
	The mulch should be left in the alleyways. To reduce spread of pathogens from soil to fruit and leaves, add straw mulch around plants and in alleyways if remaining winter straw mulch is less than 2 inches deep.
	If <u>gray mold</u> was a problem the previous year, completely remove all straw mulch from the bed and replace it with new straw.
	Mulch can be used to recover flowers if a frost is predicted.
	Do not apply nitrogen at this time. Spring applications produce an overabundance of young leaf tissue susceptible to leaf-disease fungi.
Pre-bloom	Scout for clipped buds as indicator of strawberry bud weevil activity.
	Scout for tarnished plant bug adults when flower buds are green and/or white.
	If gray mold has been a problem in past years, and weather forecasts predict high humidity or frequent rain during bloom, spray flowers with fungicide beginning when 10% of the flowers open and repeating once after the time period specified on the label.
Full bloom	Set out traps for <u>spotted wing Drosophila</u> .
Ripe fruit	Inspect for <u>slugs</u> . Apply baits if damage is detected.
	Harvest fruit as it ripens to help protect against sap beetles and spotted wing Drosophila; remove and dispose of overripe fruit.
	Take care not to wound or bruise berries during harvest.
	Remove berries infected with fruit rot to prevent spread of disease to ripening fruit. Do not place healthy fruit and diseased fruit into the same container.
Post-harvest	Renovate in the two weeks following harvest.
	Rake up and remove all leaf debris from the bed after renovation.
	Apply nitrogen fertilizers at this time.
Fall	Mulching is necessary to provide winter protection for the plants. Apply straw that is free of weed seeds two to three inches deep over the plants after they have been subjected to several sharp freezes in the low 30s or high 20s.

DISEASES

Leaf blight

Phomopsis obscurans

The leaf blight fungus infects all green parts of the plant and rarely causes a soft rot on ripening and ripe fruit. In Minnesota, leaves are most severely infected in shaded patches that have heavy dew or in years with frequent rain events.

Identification

Symptoms on leaves begin with solid reddish-purple spots that develop a tan center as they grow. As the disease progresses leaf spots enlarge to V-shaped lesions with dry brown centers with reddish purple borders. Severe infections can turn a whole leaflet brown. Fungal spore producing structures appear as black specks that dot the central area of the older lesions. These can be seen with a 10x hand lens.

Stem infections appear as reddish purple round to oval spots that never develop a tan center. Soft, mushy, pink spots form on pink to red fruit. As fruit infections age, the fruit spots become dark brown and dry.



Young round spots caused by leaf blight.
Michelle Grabowski, UMN Extension.

Important biology

The fungus that causes leaf blight overwinters in infected leaves of the strawberry plant or in infected leaf debris in the strawberry patch. Spores are released in response to moist conditions, and are transported to new leaf tissue by splashing water. Fungal spores of leaf blight require periods of extended leaf wetness (> 15 hours) to germinate. The duration of leaf wetness is the critical factor in disease development because spore germination can occur over a wide range of temperatures. Frequent rains, overhead irrigation, and heavy dews favor disease development.



Mature leaf blight symptoms with v-shaped leaf infections.
M. Grabowski, UMN Extension.

Management

- There are no strawberry cultivars that are resistant to leaf blight.
- Choose sites with full sun, good soil drainage and air circulation. This fungus requires long periods of continuous wetness to infect plants, thus any practice that promotes quick drying of leaves and fruit will reduce disease.
- Remove weeds to improve air circulation around plants.
- Plant in rows or narrow beds, no wider than 12-18 inches, to promote good air movement in and around plants. Patches grow with time as new runners are produced. Use renovation to maintain narrow beds.
- Renovate strawberry beds every year after harvest. The process is described in [*Growing strawberries in the home garden*](#).
- Following renovation, rake and remove old leaves.
- Irrigate with drip irrigation or a soaker hose. If overhead sprinkling is your only option, water early in the morning on a sunny day so leaves dry quickly after irrigation.
- Apply nitrogen fertilizers after renovation. Avoid early spring applications of nitrogen which encourage overly lush growth which reduces airflow and promotes a moist microclimate in the canopy optimal for the growth of leaf blight.



Fruit infection by *Phomopsis obscurans*, leaf blight pathogen.
Thaddeus McCamant, Northland Community College.

Fungicides

Fungicides are not considered necessary to control leaf blight in home strawberry patches. Cultural practices usually keep this disease from spreading beyond a tolerable level. Although fungicides are available that will reduce leaf blight infection, they would need to be applied regularly throughout the growing season to maintain continual protection of young leaves. This results in a significant cost, in time and resources, to the gardener. In addition, there is little evidence that reducing leaf blight infection through fungicide sprays will increase yield in following years.

Leaf scorch

Diplocarpon earlianum

In addition to leaves, leaf scorch can infect petioles, runners, fruit stalks and berry caps. If unchecked, plants can be significantly weakened reducing the growth of all plant parts. Severely

infected plants have little capacity to cope with other stresses and can die from drought or extreme temperatures.

Identification

Numerous dark-purple, angular to round spots appear on the upper surface of the leaf. As the disease progresses the tissues around these spots turn reddish or purple. In severe cases, the infected area dries to a tan color and the leaf margin curls upward looking scorched. In contrast to spots caused by leaf blight (caused by *Phomopsis obscurans*) and leaf spot (caused by *Mycosphaerella fragariae*), leaf scorch lesions will remain completely reddish purple and will not turn tan or gray in the center.



Leaf scorch. M. Grabowski, UMN Extension.

Important biology

The leaf scorch fungus overwinters on infected leaves as well as on leaf debris within the patch. The fungus can remain dormant for long periods in dry leaves, but it produces spores quickly in the presence of moisture. Spores are spread by wind or by splashing water. Spores will germinate and new leaf spots will form if leaves remain wet for 12 hours or longer. Once mature, leaf spots will produce spores throughout the growing season in response to wet conditions. These spores are spread mainly by splashing water. Hot dry weather halts disease progress.



Leaf scorch. M. Grabowski, UMN Extension.

The plant's energy resources are depleted as the number of leaf spots increases, reducing the plant's ability to do photosynthesis and store energy. As a result, severe infection by leaf scorch in summer and fall often results in reduced yield the following year. Leaf scorch infections that form on fruit and flower stalks can girdle the stalk which will kill the fruit and flower.

Management

Resistant cultivars

Although some cultivars have been reported to show resistance to leaf scorch, these have not proven to be reliably disease free in Minnesota.

Cultural control

- Choose sites with full sun, good soil drainage and air circulation. This fungus requires long periods of continuous wetness to infect plants, thus any practice that promotes quick drying of leaves and fruit will reduce disease.
- Remove weeds to improve air circulation around plants.
- Plant in rows or narrow beds, no wider than 12-18 inches to promote good air movement in and around plants. Patches grow with time as new runners are produced. Use renovation to maintain narrow beds.
- Renovate strawberry beds every year after harvest. The process is described in [*Growing strawberries in the home garden*](#).
- Following renovation, rake and remove old leaves.
- Irrigate through drip irrigation or a soaker hose. If overhead sprinkling is your only option, water early in the morning on a sunny day so leaves dry quickly after irrigation.
- Apply nitrogen fertilizers after renovation. Avoid early spring applications of nitrogen which encourage overly lush growth which reduces air flow promoting a moist microclimate in the canopy that is optimal for the growth of leaf scorch.



Leaf scorch. M. Grabowski, UMN Extension.

Fungicides

There are no fungicides available to home gardeners that effectively control strawberry leaf scorch. Cultural practices usually keep this disease from spreading beyond a tolerable level.

Leaf spot

Mycosphaerella fragariae

Leaf spot was once one of the most common and destructive fungal diseases of strawberry. Severe infection on susceptible cultivars can result in death of leaflets and defoliation of plants. Many new strawberry cultivars, however, have resistance to leaf spot and the disease is no longer as common or as problematic as it once was.

Identification

The leaf spot fungus can infect leaves, petioles, runners, fruit stalks, berry caps, and fruit. The symptoms of the disease begin with small purple spots on leaves or stems. The centers of leaf spots turn gray and then white with age. As the disease progresses multiple leaf spots merge together creating a reddish purple area with multiple round white centers. In severe cases, the leaves turn brown and die. Fruit infections are not common, but appear as small, sunken, leathery, black spots on unripe and ripe fruit. Seeds within the infected area of the fruit turn black.



In young infections of leaf spot, the white center may be difficult to see. M. Grabowski, UMN Extension.

Important biology

The leaf spot fungus overwinters on infected living leaves and in leaf debris. Spores are produced from both of these sources in the spring, and are spread to healthy tissue by splashing rain or irrigation. Cool temperatures (68 to 77° F) and long periods of leaf wetness (>12 hours) are required for new infections to develop. Consecutive wet days with temperatures between 50- 86° F favor disease development. The disease will progress as long as temperature and moisture are in acceptable ranges.



Leaf spot. M. Grabowski, UMN Extension.

Management

Resistant cultivars

Many strawberry cultivars commonly grown in Minnesota have some ability to tolerate leaf spot infection. Although leaf spots may be observed on foliage, the damage is typically not severe enough to reduce yield.

Cultural control

- Choose sites with full sun, good soil drainage and air circulation. This fungus requires long periods of continuous wetness to infect plants, thus any practice that promotes quick drying of leaves and fruit will reduce disease.
- Remove weeds to improve air circulation around plants.
- Plant in rows or narrow beds, no wider than 12-18 inches to promote good air movement in and around plants. Patches grow with time as new runners are produced. Use renovation to maintain narrow beds.
- Renovate strawberry beds every year after harvest. The process is described in [*Growing strawberries in the home garden*](#).
- Following renovation, rake and remove old leaves.
- Irrigate through drip irrigation or a soaker hose. If overhead sprinkling is your only option, water early in the morning on a sunny day so leaves dry quickly after irrigation.
- Apply nitrogen fertilizers after renovation. Avoid early spring applications of nitrogen which encourage overly lush growth which reduces airflow promoting a moist microclimate in the canopy optimal for the growth of leaf spot.



Foliage browning from leaf spot infection. M. Grabowski, UMN Extension.

Fungicide use

Fungicides are rarely necessary to control strawberry leaf spot. The cultural control practices listed above typically reduce disease to a manageable level.

Gray mold

Botrytis cinerea

Gray mold is the most common fruit rot disease of strawberries in Minnesota. The disease is most prevalent if prolonged cool, wet weather conditions exist during flowering.



Tan discoloration on fruit from gray mold infection. M. Grabowski, UMN Extension.

Identification

Infected blossoms turn from dark brown to black and do not develop into fruit. Fruit rot is most common on ripe strawberries, but a dry, tan spot caused by gray mold can occasionally be seen on white or green fruit. On ripe strawberries, gray mold infections appear as tan, soft, rotted areas that do not have a distinct border but rather fade into healthy tissue. In humid conditions, rotten areas are completely covered with velvety gray powdery fungal spores. Gray mold rot can begin anywhere on the fruit but is most common on the stem end, where the fruit comes in contact with infected flower parts or anywhere the fruit is touched by another infected berry. Ripe fruit quickly becomes completely rotten and covered in powdery, gray, fungal spores. These fruit often remain attached to the plant and dry down into gray or black mummified berries. In wet conditions, mummy berries may be completely covered with gray velvety spores.



Gray mold spreading from a spore covered mummy berry to a ripe berry.
T. McCamant, Northland Community College.

Green leaves show no symptoms of infection with the gray mold fungus. Fluffy gray spores can be found growing on the dead, brown leaf surface when leaves are killed by frost or other environmental factors. Plants damaged by winter injury may develop Botrytis crown rot, where leaf and flower stems rot and turn brown at the point where they attach to the crown of the plant.

Important biology

The gray mold fungus overwinters on dead strawberry leaves, infected straw, mummified fruit and occasionally on weeds. Spores form under cool, wet conditions and are blown by wind, splashed by rain or irrigation, or moved by pollinating insects to flowers and other susceptible tissues. The majority of fruit rot infections begin through infection of flowers. Infection is most severe in rainy or humid conditions where flowers remain wet for extended periods of time (>12 hours). Infections may blight blossoms, which become blighted and do not develop into fruit. More commonly, infections grow into the young fruit and remain dormant until the fruit begins to ripen. At this point the fungus rots the fruit and produces powdery, gray spores on the surface of the fruit. Botrytis fruit rot easily spreads to adjoining berries wherever the healthy and rotten fruit touch. Fruit infected with Botrytis fruit rot often remain attached to the plant but dry down to a shriveled mummified berry. New spores are readily produced on mummy berries during wet weather. The gray mold pathogen will colonize young leaves and remain dormant within them. When leaves die naturally, they can become an important source of gray mold spores within the strawberry patch.

Management

Resistance

Honeoye is the only cultivar recommended in Minnesota that has shown partial resistance to gray mold.

Cultural control

- Choose sites with full sun, good soil drainage and air circulation. This fungus requires long periods of continuous wetness to infect plants, thus any practice that promotes quick drying of leaves and fruit will reduce disease.
- Remove weeds to improve air circulation around plants. This will also remove any weeds infected with gray mold to prevent spread of the disease to the strawberry plants.
- Plant in rows or narrow beds, no wider than 12-18 inches to promote good air movement in and around plants. Patches grow with time as new runners are produced. Use renovation to maintain narrow beds.
- Renovate strawberry beds every year after harvest.
- Following renovation, rake and remove old leaves.
- Irrigate through drip irrigation or a soaker hose. If overhead sprinkling is your only option, water early in the morning on a sunny day so leaves and blossoms dry quickly.
- Apply nitrogen fertilizers after renovation. Avoid early spring applications of nitrogen which encourage overly lush growth that reduces airflow promoting a moist microclimate in the canopy.
- In patches with a history of gray mold, remove and discard all straw in early spring approximately when lilac flower buds appear. Place fresh straw or other organic mulch between beds to reduce rain splash and weeds and improve air movement around berries.
- Avoid wounding plants. Wounds facilitate entry of the pathogen.

Harvest recommendations

Harvest frequently and remove infected fruit from the field throughout the harvest season. Take care to keep diseased fruit separate from healthy fruit as gray mold can spread rapidly even after harvest. Handle berries with care and refrigerate soon after picking.



Gray mold. T. McCamant, Northland Community College.

Fungicides

Fungicides may be needed to protect fruit from gray mold fruit rot in years where rainy wet weather persists while plants are in bloom. In this case, fungicides should be applied during

blossom to prevent fruit rot. Read and follow all label instructions. If the season is one characterized by prolonged periods of wet or humid weather, continue spraying at the interval described on the fungicide label until petal drop. If possible watch the weather and spray before rain is predicted. Fungicides with Copper or Captan as active ingredients will reduce gray mold fruit rot in strawberry when applied properly. Fungicide sprays applied to green fruit and during fruit harvest do little to reduce disease and are not recommended.

Black root rot

Rhizoctonia fragariae, *Pythium* spp., *Fusarium* spp.

Strawberry black root rot (BRR) is the most common root disease in Minnesota. This disease is a complex problem involving several different pathogens along with a variety of plant stresses. It is common in older strawberry patches or patches stressed by poor growing conditions like soil compaction or poor drainage. The condition is aggravated by root feeding nematodes (soil borne microscopic worms) and winter injury. Plants infected with BRR decline overtime, producing significantly lower yields than uninfected plants.

Identification

The first symptoms of BRR are often missed. Infected plants have poor growth and produce fewer and smaller fruit. As the disease becomes more severe, plants are clearly stunted. Plants may wilt and the edges of leaves turn brown or have a 'scorched' appearance. Plants continue to decline and often die after the high stress of fruit production. In larger patches, disease often starts in low lying areas or areas with poor drainage. Each year the area of infected plants expands.



Above ground plant showing BRR symptoms.
P. Fiserh, Berry Crop Specialist, OMAFRA.

Plants displaying the above symptoms should be carefully dug up and washed, keeping intact as much of the root system as possible. A healthy plant will have young roots that are creamy white with multiple fine root hairs and older roots will have a dark brown to black woody outside layer but a white interior. Plants with BRR are often described as 'rat tail' because most of the finer feeder roots are rotted away leaving only the thick anchor roots. The remaining young roots have random gray to reddish brown sunken blotches. These lesions can expand to cover large areas of the root. The infected roots are soft and mushy. When touched, the outer layer often falls away, leaving only a thin strand from the core of the root.

Important biology

One or more of the black root rot pathogens are commonly found in soils. Disease develops when plants are stressed by drought, water-logged soils, winter injury, poor nutrition, and root feeding by lesion nematodes (*Pratylenchus penetrans*) or insects. *Pythium* spp., *Rhizoctonia* spp., and *Fusarium* spp. are root rotting fungi that infect and rot roots of stressed strawberry plants. This complex interaction of root rotting pathogens, environmental factors and other pests is known as black root rot. Root tips and young feeder roots may be completely rotten and fall off. Infection in older roots is limited to the outer tissues of the root; leaving a white core that is unaffected. The disease commonly occurs in fields with a long history of strawberries where the pathogenic fungi have had significant time to build-up their numbers.

Management

Prevention of black root rot is based on good site selection and proper plant care.

- At this time there are no strawberry cultivars that are resistant to black root rot, however, gardeners should choose a cultivar that is hardy in Minnesota to reduce winter injury and stress on the plant.
- Purchase new plants from a reputable supplier. Roots of young strawberry plants should be white and fleshy.
- For new patches, choose a location where strawberries have not been present for the past 2-4 years.
- Choose a location with good drainage or improve drainage before planting through adding organic matter to soil and redirecting water away from the area. Strawberries can also be planted on raised beds where drainage creates a soil environment less favorable to some root rotting fungi.
- Add organic matter like, high quality compost, peat or straw to the soil prior to planting. This will improve drainage and encourage growth of beneficial microorganisms in the soil.
- Use a soil test to determine optimum fertilizer applications for the site.
- Renovate patches of June bearing strawberries each year after harvest to maintain a healthy vigorously growing patch.
- To avoid winter injury, apply two to three inches of straw in the fall after several frost events below 20 F and above 30 degrees F.
- In existing patches with black root rot, consider starting with new plants in a new location. Do not relocate old plants to the new location as the BRR pathogens will be carried on the roots of infected plants.

Fungicides

There are no pesticides registered for use by home gardeners that are effective in controlling BRR.

Leather rot

Phytophthora cactorum

Leather rot occurs sporadically in Minnesota. The disease infects flowers and fruit at all stages. Infected strawberries have a distinctively unpleasant odor and a strong, bitter taste. Infection of a few ripe berries that are processed into jam can ruin the whole jar with this off-taste.

Identification

Infections on green fruit are typically tan to brown areas but occasionally the infected area remains green outlined by a brown margin. As the disease progresses these unripe berries become completely brown and have a rough leathery texture. Infection of ripe fruit may cause little to no color change, or the infected area may become pale, purple or brown. Rot on ripe fruit becomes dry and leathery over time. Both ripe and unripe infected fruit eventually dry down into fruit mummies.



Leather rot. S. Burkness-Wold, UMN.

Important biology

The leather rot pathogen is an oomycete; commonly called a water mold. These unique pathogens thrive in wet conditions and produce three types of spores. Oospores are tough resting spores that form in mummified berries and can survive many years in soil. These germinate when soils are saturated to produce sporangia and then zoospores. Zoospores are swimming spores that move through a film of water on the plant or soil to reach susceptible fruit and flowers. Zoospores only need two hours of moisture on the plant surface to start an infection. Once infected, sporangia are produced on fruit and are splashed by rain or irrigation to infect other fruit. The leather rot fungus thrives in areas where water stands for awhile after a rain event.



Management

- Choose a location with good drainage or improve drainage before planting through adding organic matter to soil and redirecting water away from the area. Strawberries can also be planted on raised beds to improve drainage.
- Utilize straw mulch to keep berries from contacting soil and any puddled water. Mulch will also reduce splashing of spores from the soil up onto fruit and flowers.
- Irrigate through drip irrigation or a soaker hose. If overhead sprinkling is your only option, water early in the morning on a sunny day so leaves dry quickly after irrigation.
- Pick fruit frequently and remove over ripe and diseased berries from the field.
- There are no fungicides available to home gardeners that are effective in preventing leather rot.

Anthracnose fruit rot

Colletotrichum acutatum (rarely *C. fragariae* and *C. gloeosporioides*)

Anthracnose fruit rot is a fungal disease that causes fruit rot and flower blight in warm wet weather. The pathogen is capable of infecting all above ground parts of the plant but these types of infection are less common.

Identification

Pink and red fruit develop light-brown lesions that eventually turn darker brown and sunken. Rotted areas of the fruit remain firm and dry. Pale orange to salmon colored spore masses cover the lesion during warm humid conditions. Ultimately the fruit dries down to a hard, black, shriveled mummy. Blossoms can be infected at any stage of development. Infected blossoms quickly die, dry out and turn brown. The brown discoloration often extends down the flower stalk.



Progression of anthracnose fruit rot.
Paul Bachi – U of KY, Bugwood.org.

Important biology

The anthracnose fruit rot fungus is usually introduced to a site on infected planting material. Once established at the site the fungus overwinters on infected plants, plant debris and mummified fruit. Spores are produced in a sticky mass on any infected plant part during warm (68° F) wet weather. Anthracnose spores are spread by water via splashing or wind-driven rain, and by people or equipment moving through the field. They are not airborne so they do not

spread over long distances in the wind. The fungus has the ability to attack all plant parts, however fully open flowers and ripening fruit are most susceptible to the disease. Under warm, wet conditions, the fungus will produce spores on infected fruit which spread to neighboring plants resulting in new infections.

Management

- There are no cultivars resistant to anthracnose fruit rot that are hardy in Minnesota.
- Purchase plants from a reputable supplier. Inspect all plants for symptoms of disease. Plant only healthy symptom free plants.
- Because spores are spread by splashing water, avoid the use of overhead irrigation and use drip irrigation or a soaker hose. If overhead irrigation cannot be avoided, water early in the morning on a sunny day to keep the time that the foliage is wet to a minimum.
- Maintain one to two inches of straw mulch between the rows or walking alleys to reduce splash dispersal of disease spores.
- Remove infected berries from the planting during harvest to reduce spread of the disease to developing fruit.

Fungicides

If anthracnose has been a problem in the past and weather is warm and wet during flowering and fruit production, fungicides can be applied to reduce infection. Anthracnose is not easily controlled by fungicides and gardeners should expect a reduction in disease but not complete protection. Fungicides with Copper, Captan or *Bacillus subtilis* listed as the active ingredient provide some protection from anthracnose fruit rot. All label instructions must be read and followed when applying a pesticide.

Angular leaf spot

Xanthomonas fragariae

Angular leaf spot (ALS) is caused by a bacterium that primarily infects leaves. Although angular leaf spot was originally discovered in Minnesota in 1960, this disease is not a common problem today.



Severe infection with angular leaf spot.
U. Mazzucchi, Università di Bologna, Bugwood.org.

Identification

The first symptoms of angular leaf spot are water-soaked lesions on the underside of the leaf that are delineated by leaf veins creating an angular appearance. These lesions are best observed by

picking a leaf and holding it up to the light, looking at the lower surface of the leaf. The spots will appear translucent with light behind them but will look dark green when the leaf is held in your hand. As the disease progresses the damage becomes visible on the upper surface of the leaf as reddish brown spots surrounded by a yellow halo. Heavily infected leaves may die. In warm wet weather, bacteria ooze out of infected tissue in slimy droplets that dry to a clear scaly film, similar to dried egg white. In severe infections, lesions can appear on the fruit caps that are identical to those on leaves. As the disease progresses the calyxes can also become dark brown and later dry up (ALS 6).

Important biology

Angular leaf spot bacteria are usually introduced to a berry patch on transplants that are infected but not showing symptoms. Under favorable weather conditions the bacteria ooze from leaf tissue and are dispersed by rain splash. The bacteria can then invade other plants through wounds or natural openings. This disease thrives in wet conditions with moderate daytime high temperatures (~ 68° F) and cold nights close to but above freezing (36-39° F). The angular leaf spot bacteria can overwinter in the crowns of live plants or in leaf debris.



Water soaked appearance of lower leaf infected with angular leaf spot.
D. Ferrin, Louisiana State University, Bugwood.org.

Management

- At present there are no strawberry cultivars resistant to angular leaf spot; however there is variation in susceptibility. The following cultivars have been shown to be highly susceptible, and should be avoided if angular leaf spot has been a problem in the past: Allstar, Annapolis, Cavendish, Honeoye, and Kent.
- Purchase new plants from a reputable supplier and inspect all plants for symptoms of disease prior to planting. Accept only healthy symptom free plants.



Dark sepals infected with angular leaf spot.
G. Holmes, Valent Corporation, Bugwood.org.

- Irrigate through drip irrigation or a soaker hose. If overhead sprinkling is your only option, water early in the morning on a sunny day so leaves dry quickly after irrigation.
- Avoid working in an infected patch when the plants are wet as bacteria are easily spread on hands and tools at this time.
- Use straw mulch to minimize water splashing.
- Remove weeds to improve air circulation around plants.
- Plant in rows or narrow beds, no wider than 12 - 18 inches to promote good air movement in and around plants. Patches grow with time as new runners are produced. Use renovation to maintain narrow beds.
- Renovate strawberry beds every year after harvest. The process is described in [*Growing strawberries in the home garden*](#).
- Following renovation, rake and remove old leaves.
- Although fungicides with copper as an active ingredient have been shown to reduce the number of leaf spots caused by ALS, these applications do not affect yield and are not recommended.

Powdery mildew

Podosphaera aphanis

(Formerly *Sphaerotheca macularis* f. sp. *fragariae*)

Powdery mildew is a fungal disease that infects leaves and occasionally fruit. Powdery mildew thrives under conditions of low light intensity and warm humid weather. As a result powdery mildew is common in greenhouse-grown plants but occurs only occasionally in gardens.

Identification

White patches of fungal growth develop on the lower leaf surface. In some cultivars, this fluffy white growth is thick, abundant and can cover the entire leaf surface. In other cultivars, the fungal growth is thin and difficult to see. Some cultivars develop purple to red blotches when infected. The leaf margins of infected plants frequently roll upwards. Infected fruit have raised seeds, a bronze cast to the fruit, and have patches of fluffy white fungal growth.



Leaf curl and purple discoloration on infected leaves.
Ontario Strawberry IPM, OMAFRA.

These fruit symptoms are similar to symptoms caused by thrips. Use a hand lens to look for white fungal growth around the seeds, which is characteristic of powdery mildew. Bronzing on the

underside of calyx tissue would indicate feeding by thrips. Some day-neutral cultivars are susceptible to fruit infection in fall even though leaves may appear healthy.

Important biology

The powdery mildew fungus is most commonly introduced into a garden on contaminated transplants but can be present on wild strawberries as well. The fungus overwinters in live infected plant tissue. Spores are carried short distances by wind and, unlike most fungal diseases, can germinate on dry leaf surfaces given high humidity. Powdery mildew is favored by warm (60 - 80°F) weather with high humidity. Frequent rain, dew or irrigation slows the progress of disease. The disease can establish in the spring if there are extended periods of warm weather and high humidity. More often the disease establishes in mid to late summer where cooler nights lead to high humidity conditions favorable for infection.

Management

- Although some cultivars have been reported to show resistance to powdery mildew, these have not proven to be reliably disease-free in Minnesota.
- Purchase plants from a reputable supplier. Inspect all plants for symptoms of disease. Plant only healthy symptom free plants.
- Renovate strawberry beds every year after harvest. The process is described in [*Growing strawberries in the home garden*](#).
- Following renovation, rake and remove old leaves.



Powdery mildew causing bronzed fruit and raised seeds.
Ontario Strawberry IPM, OMAFRA.

Fungicides

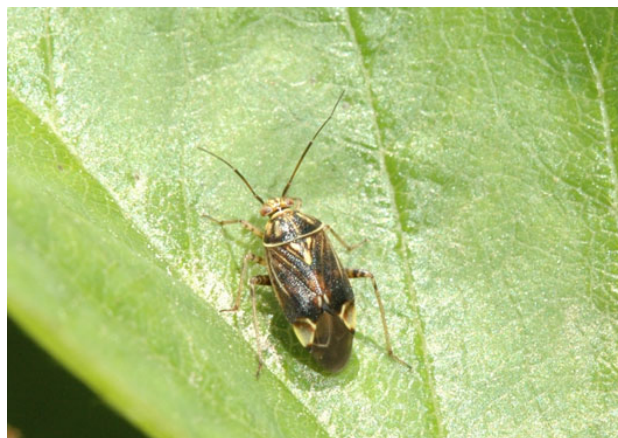
Fungicide sprays may be necessary to protect plants after summer renovation if powdery mildew has been identified in the patch before renovation. Several fungicides are available to control powdery mildew. Choose products with an active ingredient of myclobutanil, sulfur, potassium bicarbonate, or horticultural oil. Apply products according to the label instructions. Repeated applications will be necessary as long as conditions favorable for disease continue. Do not use sulfur on fruit intended for canning.

INSECT PESTS

Tarnished plant bug

Lygus lineolaris

The most important insect pest of Minnesota-grown strawberries is the tarnished plant bug (TPB). Heavily infested fruit is severely deformed and unappealing.



Tarnish plant bug adult. Note the V or Y marking on its body.
Jeff Hahn, University of Minnesota.

Identification

TPB adults are about 1/4 inch long and oval shaped. They are brown to black with yellow or white patches. They are easily identified by the yellow markings behind the head which vary from a V shape to a Y shape to a heart shape. The nymph is similar to the adult only smaller. They are green with black spots.



Tarnished plant bug nymph. J. Hahn, University of Minnesota.

Important biology

Adult TPB emerge from overwintering sites in early spring and prefer to feed on the rapidly growing plants just beginning their spring growth. The adults are active for several weeks prior to the opening of strawberry flowers. At flowering time the females mate and insert their eggs into the flower blossoms. The female will lay 3 to 4 eggs per day. The nymphs emerge a week or so later and begin feeding on the flower tissue. There can be 2 to 5 generations per year. In the fall the adults look for leaf litter, tall grass, or weedy areas in which to spend the winter.

Damage

Both adults and nymphs injure strawberry fruit by inserting their piercing mouth parts into the flowers and young fruit. This kills the developing seeds and the surrounding tissue resulting in a deformed fruit often called a "button berry". The adults are responsible for most of the damage to strawberry flowers and fruit. Damage can vary from partial to severe depending on the amount of feeding and the numbers of bugs present.



Tarnished plant bug damage on strawberries.
T. McCamant Central Lake College.

Management

Monitoring

Inspect for TPB soon after strawberry plants have begun to grow in the spring. Look for adults feeding on the emerging buds in either the green or white stage. Research indicates that the best strategy is to manage adult numbers at this stage.

Non-chemical

- Remove leaf litter to reduce the number of overwintering sites for TPB.
- Remove weeds as they can provide habitat for adults to feed and overwinter.
- Keep lawn areas properly mowed so that the lawn does not become a TPB habitat area.
- If your patch is small enough, you can physically remove TPB by tapping the flowers and dislodging the insects into a pan of soapy water.
- Renovate the patch to remove potential habitat and reduce insect numbers.

Insecticides

Make spray applications on the basis of scouting results when TPB adults are found in either the green or white stage. Effective insecticides are permethrin, carbaryl, and malathion. Be sure to read and follow all pesticide label directions.

Strawberry bud weevil

Anthonomus signatus

The strawberry bud weevil (SBW) or "clipper" can be a common pest of strawberries. Bud weevils are rare in the southern three tiers of counties in Minnesota, but can be more common in the rest of the state.

Identification

The SBW is a small (about 1/10 - 1/8 inch long), reddish brown weevil with a long snout equipped with feeding mouth parts.

Important biology

SBW emerges in the spring when strawberry buds first begin to develop. The adults move from their overwintering sites in fence-rows, wooded areas, and berry fields as temperatures reach 60° F in late April or early May. Bud weevils rarely fly or walk more than 30' while looking for food or places to lay eggs. Once they find strawberries, females chew holes in the buds to lay their eggs. Egg-laying peaks during early bloom.

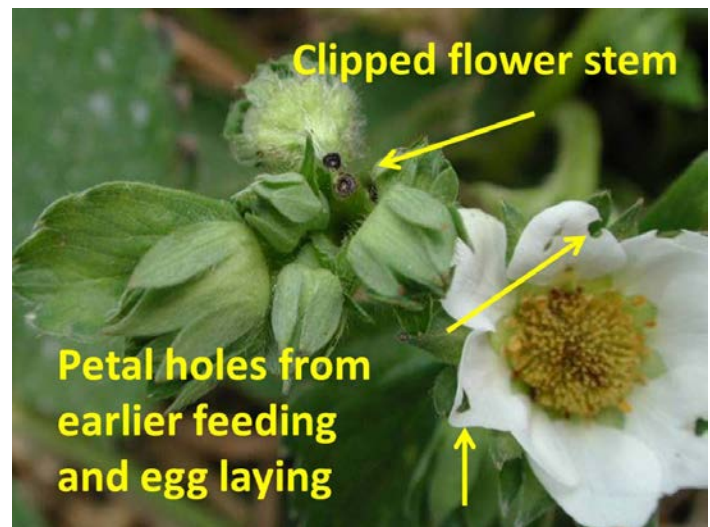


Strawberry bud weevil in strawberry flower. University of Georgia Plant Pathology Archive, University of Georgia.

After that, the females clip off the stems (peduncle) which often fall to the ground. The larvae feed in the flower bud for three weeks. The larvae then pupate either in the bud or in the soil with adults emerging in late June through July. These adults feed on pollen from various flowers for a short time and then seek overwintering sites in late summer. There is one generation per year.

Damage

The most important injury is caused by the adult females when they damage flower buds and stems. This damage ultimately reduces the amount fruit that is produced. Damage by SBW in home gardens is usually minor but has the potential to be severe under the right circumstances.



Clipped flower stem due to strawberry bud weevil.
Ontario Strawberry IPM, OMAFRA.

Management

Monitoring

Begin sampling for clipped buds when day time high temperatures reach 60 to 65° F and the blossom buds are just starting to emerge from the crown (unexpanded flower clusters). This will require examination close to the ground. Inspect your strawberries at least twice a week. It is not necessary to check strawberries once the buds are open.

Non-chemical

- Remove weeds near strawberries that are a pollen-feeding source for newly hatched SBW.
- Practice renovation as mowing and removing foliage after harvest removes overwintering sites for the weevils.

Insecticides

If you find at least one clipped bud for every four to five plants, consider treating your strawberries. Count only the newly clipped green buds and not the older clippings which will be shriveled and dry. If the threshold is exceeded seven days after the first spray, another spray application can be made. Be careful with an application as the primary flowers may be opening and the insecticides used for SBW are toxic to bees. Effective insecticides for treating SBW are permethrin, malathion, and carbaryl. Be sure to read and follow all pesticide label directions.

Spotted wing Drosophila

Drosophila Suzuki

Spotted wing Drosophila (SWD) was first found in Minnesota in 2012. There are still many questions as to how SWD will impact strawberries and other fruit in Minnesota. Damaging populations so far have impacted fruits ripening in August and later. This suggests that the most vulnerable strawberries are ever-bearing (day-neutral) cultivars that begin ripening in July and continue to frost. June-bearing strawberries are much less likely to be infested.



Male spotted wing drosophila. Note the dark spot on tip of wing.
Bob Koch, University of Minnesota.

Identification

SWD can be difficult to distinguish from similar flies. SWD is a small fly, only 2 - 3 mm (1/12 - 1/8 inch) long, with yellowish-brown coloration and prominent red eyes. The males are fairly easy to identify - they have clear wings and a dark spot along the first vein near the tip of each of wing.

Female SWD also have clear wings, but lack any spots on them which makes them difficult to identify. The ovipositor used by the female fly to insert eggs into berries has large, dark-colored

teeth which permit her to puncture immature fruit. This can only be viewed under high magnification, (e.g. a dissecting microscope).

SWD larvae (also called maggots) are white with a cylindrical body that gradually tapers on one end. This is a small insect, only reaching 1/8th inch long.

Biology

Adult flies insert eggs into soft fruit where the larvae develop. The larvae will then leave the fruits to pupate and later emerge as adults. SWD can complete its life cycle in as little as seven days. Multiple generations of SWD can occur in a year, with populations building throughout the summer. SWD overwinters as an adult; there is increasing evidence that SWD is able to survive Minnesota winters to some extent.



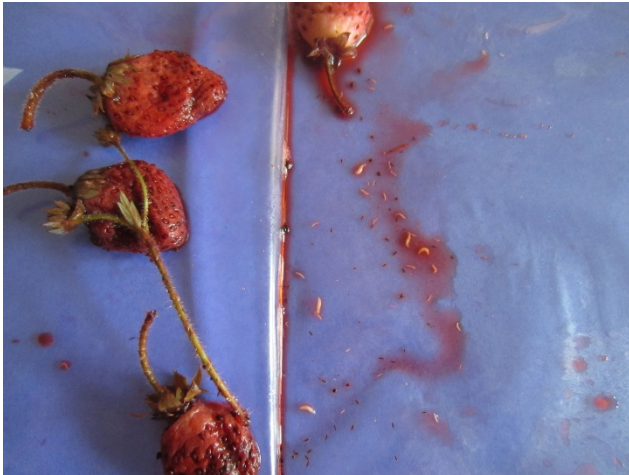
Close up of female's ovipositor showing large dark teeth.
Hannah Burrack, North Carolina State University.

Damage

SWD larvae feed on healthy, intact, ripening strawberries. SWD can also attack other soft-skinned fruit, such as raspberries, blackberries, cherries, blueberries, plums, and grapes. SWD larvae feed within the strawberries causing brown, sunken areas. Eventually, the fruit becomes soft and decomposes. It is possible these symptoms won't appear until after the crops are harvested. In addition to the damage caused directly by the larvae, the feeding makes the fruits susceptible to infestation by other insects, rot fungi, and bacteria.



Spotted wing Drosophila larvae in strawberry.
Hannah Burrack, North Carolina State University.



Spotted wing *Drosophila* damage to strawberries.
Eric Burkness, University of Minnesota.

Management

Monitoring

Monitoring should occur from fruit set until the end of harvest. This allows home gardeners to identify the start and end of fly activity, although the most critical time period to monitor is when fruit color first starts to develop until the crop is harvested. This is when strawberries are susceptible to SWD infestation.

Adult SWD flies can be trapped using a plastic 32oz cup with several 3/16"-3/8" holes around the upper side of the cup, leaving a 3-4 inch section without holes to hold the bait. Holes can be made using a drill in sturdy containers or, if in softer material, burned with a hot wire or soldering iron. The small holes allow access to SWD, but keep out larger flies and other insects.



Homemade trap for capturing spotted wing *Drosophila* adults.
Michigan State University.

Pour one inch of apple cider vinegar into the trap as bait. To capture flies, place a small yellow sticky card inside. Yellow sticky cards can be purchased from local garden supply companies and from [Gempler's](#). The traps will also work without the yellow sticky insert, but then add a drop of unscented dish soap to the vinegar so the flies remain trapped in the liquid.

Place traps on a stake just above the canopy in the row, and begin monitoring before the strawberries begin to ripen. Make sure the trap is clear of vegetation with holes exposed so that SWD can easily enter the trap.

Cultural

Sanitation is important to reduce the local buildup of SWD populations. The best sanitation practice is to frequently harvest crops to ensure ripe fruits are not in gardens for extended

periods of time. It is also important to remove and destroy any old fruit that remains on stems or that has fallen to the ground.

Insecticides

It is important to remember that SWD females can start laying eggs one day after adult emergence. This makes it very important to monitor to detect whether SWD is present and when they first appear. The sooner the flies are discovered, then the quicker management decisions can be made. SWD will complete multiple, overlapping generations so there will be continuous activity once the flies become active. Insecticides are used to prevent the females from laying eggs. It does not affect the larvae once they have infested the fruit. Effective chemicals are permethrin, spinosad and malathion. Be sure to read and follow all pesticide label directions.

Spittlebugs

Including meadow spittlebug,
Philaenus spumarius

Spittlebug is a common insect in strawberries in Minnesota home gardens but it is not usually damaging enough to be considered a problem. The nymphs create a foamy mass that they use for protection.



Spittlebug foamy mass. J. Hahn, University of Minnesota.

Identification

The easiest way to identify spittlebugs is from the presence of the 'spittle' they create. These spittle masses can be up to 3/4 inch in size. The nymphs are inside. They are soft-bodied, elongated, yellow to green in color, and up to 1/4 in. in length. The adults are 1/4 inch long; they start out green and then turn brown or grey, although they are not usually seen.



Immature spittlebug hidden in 'spittle'. J. Hahn, University of Minnesota.



Immature spittlebug. R. Bercha, insectsofalberta.com.

Important biology

Spittlebugs overwinter as eggs. Nymphs emerge in late April or early May and start feeding at the base of the plants, but continue to move up, preferring tender foliage and blossom tissues. The nymphs mature in 5 - 8 weeks and as adults migrate to nearby grassy areas, pastures or areas with broadleaf weeds. The females return in September and October and lay clusters of eggs amongst plant debris or in leaves and stems. There is only one generation per year.



Adult spittlebug. J. Hahn, University of Minnesota.

Damage

Spittlebug nymphs pierce the plant stems and suck plant juices. In most cases, spittlebug feeding is not damaging to plants. If large populations are present, feeding can cause leaves to become distorted and berries stunted.

Management

The spittlebug's foam is easily recognized. In late April or early May begin by looking for spittle and nymphs in the crown area at the base of the plants. Check every 2 weeks and as the plants grow begin to inspect the underside of young leaves as well as the crown area.

Spittlebugs will begin to be annoying at 1 spittle mass per sq. ft. a so called "aesthetic threshold". At 5 or more spittle masses per sq. ft. yields can be affected.

- Remove weeds that are an attractive habitat for spittlebugs.
- Physically remove the spittlebugs by hand when it is practical.

- The spittlebug froth protects the insects from chemicals. Fortunately, insecticides are rarely, if ever needed.

Sap beetles

Including strawberry sap beetle (*Stelidota geminata*)
(*Glischrochilus quadrisignatus*)

Sap beetles are a common group of insects in home gardens. Two species that are particularly attracted to the ripe strawberries in Minnesota are the strawberry sap beetle and picnic beetle.



Strawberry sap beetle. Tom Murray.

Identification

Sap beetles are generally small insects, usually less than 1/2 inches long with oval-shaped bodies. They are generally dark colored, sometimes with orange or yellow spots.

The adult strawberry sap beetle is dark brown, oval, less than 1/8-inch long, and has no prominent markings on the wings. The adult picnic beetle is somewhat longer at 1/5-inch long, is thinner, and has four orange blotches on the back. Look for the "knobbed" antennae when identifying sap beetles.



Picnic beetle. T. Murray.

Important biology

Sap beetles overwinter as adults in organic matter in protected sites and become active early in spring. They will mate and begin laying eggs in fermenting material in May and June. Adults emerge in late June and July.

When the strawberries begin to ripen, sap beetles are attracted into gardens.

Strawberries are the primary host for the strawberry sap beetle which prefers over-ripe fruit but will also readily attack ripening fruit. The strawberry adult sap beetle tends to feed on the underside of berries creating holes. The picnic beetle is attracted to all types of over-ripe and damaged fruit. Beetles usually overwinter in sites outside gardens. There is usually only one generation per year.



Sap beetle damage to strawberries. Natalie Hummel, Louisiana State University AgCenter.

Damage

Sap beetles feed on ripe and overripe strawberries, sometimes congregating in large numbers. They can leave deep cavities in the berries, an injury similar to slug injury. At the same time they introduce fungal spores of organisms that can further decay the fruit.

Management

Monitoring

Watch for sap beetles in gardens starting in early July when adults first start to emerge. Particularly check overripe strawberries, although they can also be found in ripening fruit.

Cultural

Keep the field clear of ripe and over-ripe fruit, as reducing the attractant is the best management tactic. Place "trap buckets" baited with whole wheat bread dough and over-ripe fruit outside the patch to intercept immigrating beetles and reduce numbers. The beetles are highly attracted to anything that has the ability to ferment.

Insecticides

Chemical control is not effective for several reasons. First, the beetles are moving into the fields from other areas and killing the ones in the field is no guarantee that others will not enter the field following the spray. Second, populations do not build up until harvest so nothing preventative can be done.

Slugs – (various species)

Slugs are shell-less mollusks that will feed on ripe strawberries.

Identification

Slugs have fleshy slimy legless bodies that are predominantly different shades of gray. Slugs are basically snails with a reduced shell located internally. Their head contains two pairs of feelers; a larger pair above carries the eyes and a lower pair below is used for smelling. Most slugs in strawberries range in length from 1/4" to 1 1/2".



Typical slug. J. Hahn, University of Minnesota.

Important biology

Slugs have a layer of slime to protect their skin from desiccation. As they move, they leave a slime trail which can be used to identify their presence. They prefer moist habitats and locations where they can escape the sun. They feed at night or on dark, overcast days. Slugs lay their translucent eggs under plant debris or in the soil, where the moist conditions provide for optimum development of eggs and young. Continuous straw mulch in a strawberry patch provides such an ideal habitat. Slugs seek out straw mulch and other types of mulch to lay their eggs in the fall and these eggs will hatch in the following spring with the slugs feeding on strawberries in the spring and early summer.

Evidence of slug activity comes in two forms, slug movement and slug feeding. Slugs continually produce slime on which they move and it is a dried slime trail that indicates their travel the previous night.

Slugs have an anatomical structure called the radula which contains small teeth made of chitin. The radula is a rasping organ which scrapes or cuts food before being ingested, and it is the structure that damages the strawberry fruit.



Slug damage on strawberry. Ontario Strawberry IPM, OMAFRA.

Damage

Slugs create varying size holes in the strawberry fruit. The damage can vary from minor practically unnoticeable scraping on the surface of the fruit to significant cavities equal to half of the fruit. When present in large numbers significant damage can be done to the fruit.

Management

Monitoring

Slugs should be monitored during and after bloom. In the day look for slime trails in the patch or place wooden boards in the straw underneath which slugs will congregate. Pick up the boards to see monitor slug populations. Keep especially vigilant for slugs during extended periods of overcast and rainy weather. In the evening use a flashlight to check for slugs.



Slugs hiding under board. Jack Kelly Clark, University of California.

Cultural

- Remove potential hiding places for slugs such as weeds vegetation and debris.
- Water plants early in the morning to permit all day drying, which avoids creating a moist habitat ideal for slugs.
- Place drip irrigation tape close to the plants and avoid creating wet mulch situations which are ideal habitats for slugs.
- If you plant in rows keep the width of the rows narrow (12 to 18 in.) to allow quicker drying
- Place traps, such as wooden boards and rolled-up newspapers in the patch. Check traps first thing in the morning every day and dispose of the slugs.
- Create a slug trap by pouring beer into a shallow pan buried so that the edge is at ground level. Slugs are highly attracted to smells emitted from fermentation processes, and will fall into the pan and drown. Check and renew the trap every couple of days.

Pesticides

Baits need to be considered as a part of a cultural program and employed in conjunction with other methods. Baits alone will not effectively control slugs.

Baits need to be applied prior to the ripening of the berries because the slugs prefer ripe berries to slug bait.

The patch should be irrigated prior to placing the baits to create a situation that will encourage the slugs to be more active. Apply the bait in the late afternoon or evening close to the time when the slugs will begin activity. Sprinkle some bait in protected area where you think the slugs might be hiding such as areas close to walls or fences and in areas which you think the slugs might have to traverse to get to the patch.

Iron phosphate

Baits that contain iron phosphate don't kill as many slugs as those with metaldehyde, but seem to protect the crop well enough. Iron phosphate baits are cleared for organic production and are safe around children and pets. Baits break down after rains or irrigation. Iron phosphate kills more

slowly than metaldehyde and the slugs will seek a hiding place and die there. You may not see slug casualties when you use iron sulfate.

PESTICIDE TABLES

Table 2: Fungicides

Chemical	Pest controlled	Trade name examples
<i>Bacillus subtilis</i>	Anthrachnose	Serenade, AgraQuest, Inc.
copper octanoate* copper sulfate* liquid copper	Gray mold, Anthracnose	Lily Miller Cueva Copper Soap Fungicide Natural Guard Copper Soap Elementals Garden Disease Control Bonide Liquid Copper
myclobutanil	Powdery mildew	Spectracide Immunox Multi-Purpose Fungicide
sulfur	Powdery mildew	Lily Miller sulfur dust
Potassium bicarbonate	Powdery mildew	Greencure
captan	Gray mold, Anthracnose	Bonide Captan

Table 3: Insecticides

Chemical	Pest controlled	Trade name examples
spinosad	Spotted wing Drosophila	Natural Guard Spinosad
malathion	Tarnished plant bug, Strawberry weevil, Spotted wing Drosophila	Ortho Max Malathion
carbaryl	Tarnished plant bug, Strawberry weevil	Garden Tech Sevin
permethrin	Tarnished plant bug, Strawberry weevils	Bonide Eight Vegetable Fruit and Flower Conc., Hi Yield Indoor/Outdoor broad use insecticide
iron phosphate	Slugs	Elementals Slug and Snail Killer, Safer Brand slug and snail bait, Bonide Slug Magic

*Repeat application of copper materials have caused phytotoxicity whose symptoms are the reddening of older leaves, slow plant growth, and yield reduction

Caution: Read all pesticide labels prior to use and follow all instructions. The information contained in this document is not a substitute for a pesticide label. Pesticide labels may change. Before using any pesticide, verify that it is labeled for use on strawberries. Trade names are for demonstration purposes only and do not imply endorsement by UMN Extension. Trade names may change over time. Products with the same active ingredient but different trade names should offer disease control as well.